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The effectiveness of two circuits (constant current = skin resistance; constant voltage = skin conductance) used for measuring electrodermal activity during a psychophysiological detection of deception (PDD) examination were researched in an analog study conducted by the Department of Defense Polygraph Institute (DoDPI). Thirteen DoDPI instructors tested a group of 65 subjects who had been assigned to one of four conditions: (1) innocent, (2) guilty of one mock crime, (3) guilty of two mock crimes, or (4) guilty of three mock crimes. Half the subjects were tested with a multiple issue test format which contained questions about all three crimes under investigation. The remaining subjects were tested using a series of three single issue examinations, each containing questions about only one crime. Following the examinations, two objective measurements were made on the skin conductance response and skin resistance response waveforms. One measurement assessed the number of centering adjustments made during the examination, and the other measurement compared the electrodermal responses (to the nearest millimeter) for both the relevant and the control questions. The constant voltage circuit (skin conductance) required approximately half the number of centering adjustments as the constant current circuit currently in use throughout the polygraph field. Because the two circuits do not have the same scale, sensitivity settings could not be compared. However, when the actual size of the electrodermal responses were compared the differences were not statistically significant—suggesting that numerical scores and resultant decisions based upon those responses would have been the same.

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The Relative Utility of Skin Resistance and Skin Conductance

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Abstract

BARLAND, G. H., HONTS, C. R., and BARGER, S. D. The Relative Utility of Skin Resistance and Skin Conductance. January 1990, Report No. DoDPI90-R-0005 Department of Defense Polygraph Institute, Fort McClellan, AL 36205.--The effectiveness of two circuits (constant current = skin resistance; constant voltage = skin conductance) used for measuring electrodermal activity during a psychophysiological detection of deception (PDD) examination were researched in an analog study conducted by the Department of Defense Polygraph Institute (DoDPI). Thirteen DoDPI instructors tested a group of 65 subjects who had been assigned to one of four conditions: (1) innocent, (2) guilty of one mock crime, (3) guilty of two mock crimes, or (4) guilty of three mock crimes. Half the subjects were tested with a multiple issue test format which contained questions about all three crimes under investigation. The remaining subjects were tested using a series of three single issue examinations, each containing questions about only one crime. Following the examinations, two objective measurements were made on the skin conductance response and skin resistance response waveforms. One measurement assessed the number of centering adjustments made during the examination, and the other measurement compared the electrodermal responses (to the nearest millimeter) for both the relevant and the control questions. The constant voltage circuit (skin conductance) required approximately half the number of centering adjustments as the constant current circuit currently in use throughout the polygraph field. Because the two circuits do not have the same scale, sensitivity settings could not be compared. However, when the actual size of the electrodermal responses were compared the differences were not statistically significant--suggesting that numerical scores and resultant decisions based upon those responses would have been the same.

Key words: polygraph examinations, electrodermal response, skin conductance, skin resistance.

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There presently are two circuits commercially available to polygraph examiners for the measurement of electrodermal activity (galvanic skin response). The more common of those circuits, and the one in general use in the Federal polygraph community, is a constant current circuit that measures skin resistance directly. The other circuit, a constant voltage circuit measures skin conductance directly.

Following a watershed publication by Lykken and Venables (1971) most of the scientific community abandoned the constant current circuit in favor of the constant voltage circuit. The constant voltage circuit is now considered the standard for scientific publication (Fowles, et al., 1981). Scientific preference for the constant voltage circuit is based on three factors. First, because of the nature of electricity, a direct measure of conductance is more likely to directly represent the physiological activity of interest, namely the number of and activity level of active sweat glands. Second, when the skin resistance is high, that is when few sweat glands are active, the constant current circuit may cause the current density flowing through the few active glands to become very high. This high current density in turn may have very undesirable effects on the glands themselves. It is possible that many of the "plunging" galvanic skin response(GSR) tracings seen on field polygraph charts are due to such current density effects. Due to its nature the constant voltage circuit does not suffer from this problem. Finally, due to the scaling of the circuit outputs and the lack of a current density problem, Lykken and Venables asserted that the constant voltage circuit should require about half as much centering adjustment as does the constant voltage circuit.

If the constant voltage circuit does reduce plunging tracings and require about half as much adjustment as the constant current circuit, then adoption of the constant voltage circuit by the polygraph community would be useful and desirable. We examined both circuits by measuring both skin resistance and skin conductance fromthe same subjects in a laboratory experiment.

Method

The subjects were 61 male and 4 female enlisted trainees at For McClellan. The average age of subjects was 20.2 years. Subjects were randomly assigned to one of four conditions of equal size. One condition was an innocent condition and the other three were guilty conditions. Subjects assigned to the first guilty condition enacted one of three possible acts of espionage or sabotage. Subjects assigned to the second guilty condition enacted two of the three possible acts, and the remaining guilty subjects enacted all three mock crimes.

The polygraph examinations were conducted by 13 instructors from the Defense Polygraph Institute. During their polygraph examinations, subjects were treated as if they were criminal suspects. A stimulation (number) test was administered before the first chart. Two different types of polygraph examinations were administered. Half of the subjects were tested with three single issue examinations, and half were given one multiple issue examination. Single Issue subjects were given three single issue control question tests, one after the other. Each test covered one crime and consisted of three repetitions of the questions. The sequence in which the crimes were covered was systematically varied to control for possible sequence effects. There were two relevant questions and three control questions in each of the three single issue tests. The multiple issue test administered to the remaining subjects used the same six relevant questions in a single series with four control questions. That multiple issue series was repeated three times.

Following data collection an assistant who was not aware of each subject's guilt status made objective measurements of the skin conductance response (SCR) and skin resistance response (SRR) waveforms. Two measurements were made. First, all examiner centering adjustments that occured between the point where the examiner told the subject the test was about to begin and the point where the examiner told the subject the test was over were measured to the nearest millimeter. Then all of the electrodermal responses to the relevant and control questions were measured to the nearest millimeter. The following rules were used in making those measurements. Responses of 3mm of less in magnitude were considered zero response. Response magnitude was measured from the lowest point following question onset, but preceeding response onset, to the peak of the largest response wave that began no later than 5 seconds following the subjects answer.

It would have been interesting to examine the number of adjustments as well as the amount of adjustment, however this was not possible. In lieu of instructions to the contrary, examiners tended to center both tracings at the same time even if one really did not require recentering. Additional research is being planned at the Institute to examine differences between the two circuits in the number of required recenterings in a large between subjects design.

Results

Results for the amount of centering required are illustrated in Figures 1 and 2. The constant voltage circuit that measures skin conductance directly required only about half as much adjustment as did the constant current circuit that is now standard in field applications. Those differences were statistically significant.

There was a concern that the differences in amount of required adjustment might reflect differences in sensitivity. Since it was not possible to compare sensitivity settings, they are not on the same actual scale, we compared the actual size of the responses with the two circuits. They were not statistically different. This strongly implies that neither the numerical scores nor the resultant decisions based on those scores would have been different. These also strongly suggest that the adjustment differences between the circuits reflect actual differences in required adjustment. The means for the electrodermal measures are illustrated in Figures 3 and 4. As expected Innocent subjects produced larger electrodermal responses to control questions than they do to releveant questions, and Guilty subjects produced larger electrodermal responses to relevant questions than they did to control questions. These interaction effects were statistically significant for both the single and multiple issue conditions.

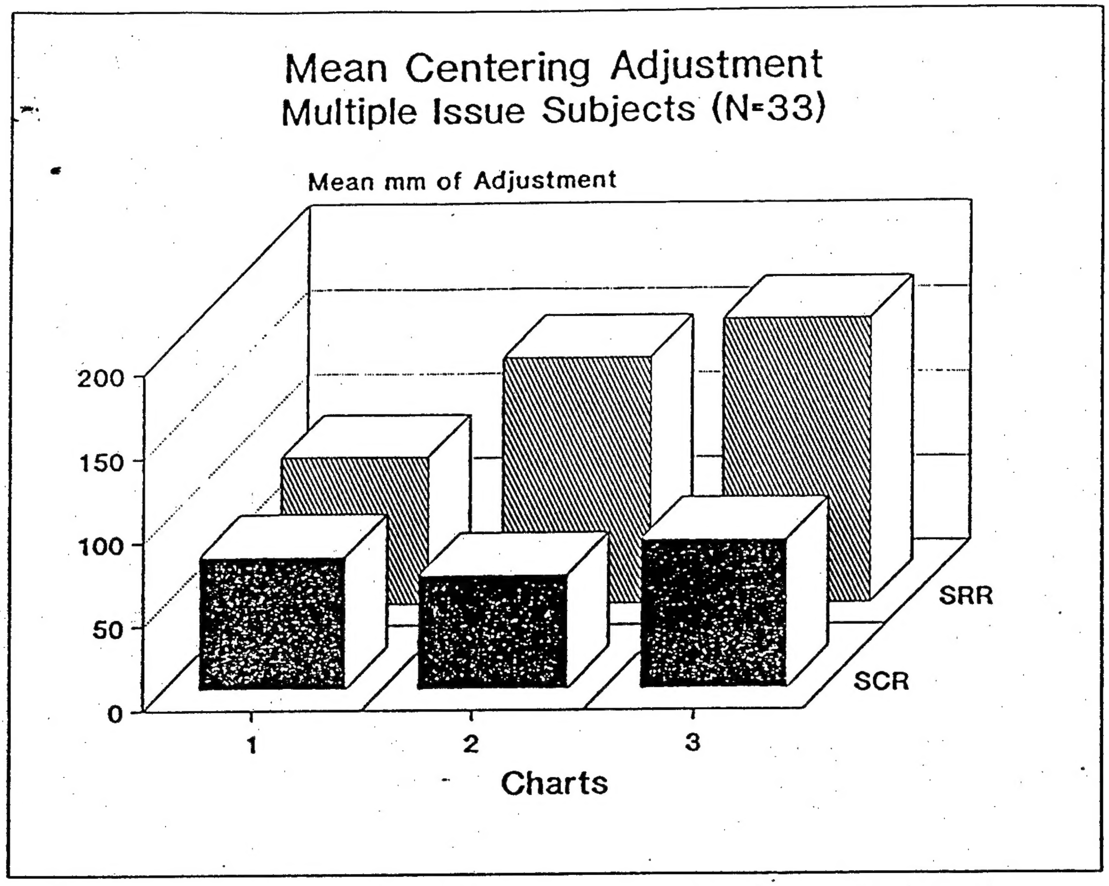

Figure 1. Mean millimeters of centering adjustment required for the skin conductance and skin resistance circuits in the multiple issue condition.

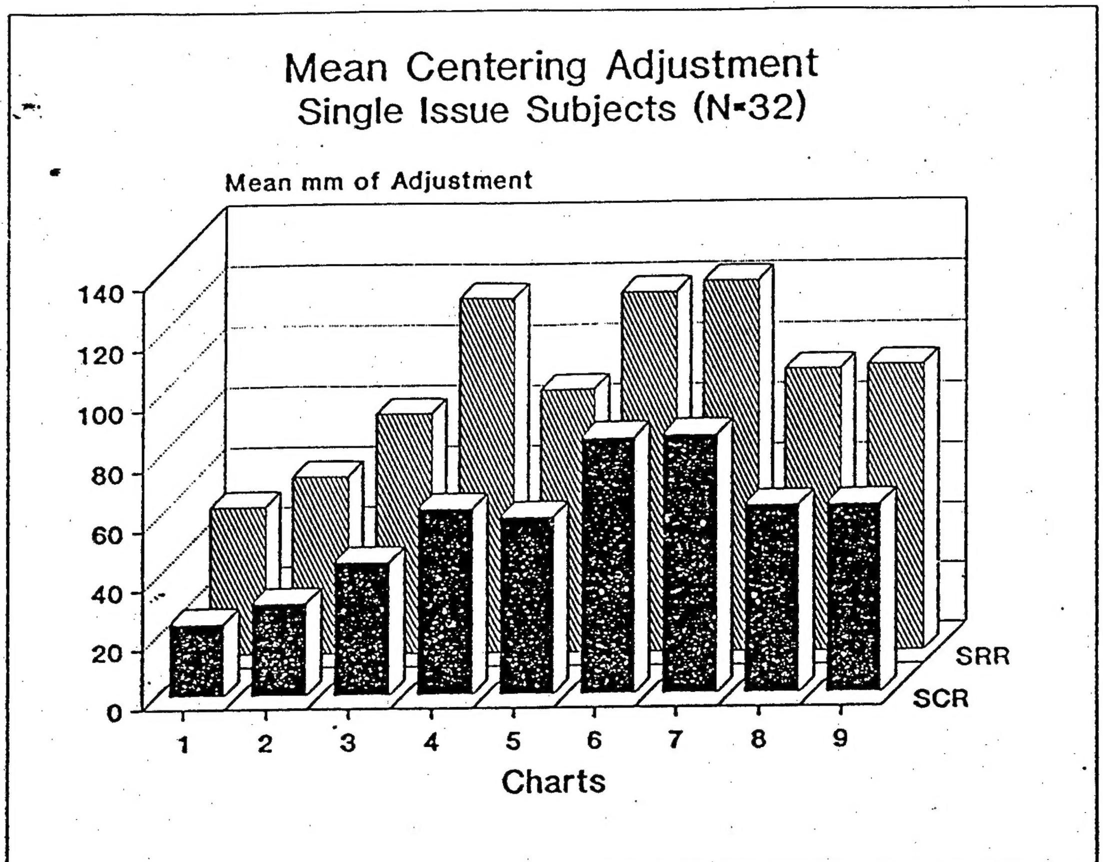

Figure 2. Mean millimeters of centering adjustment required for the skin conductance and skin resistance circuits in the single issue condition.

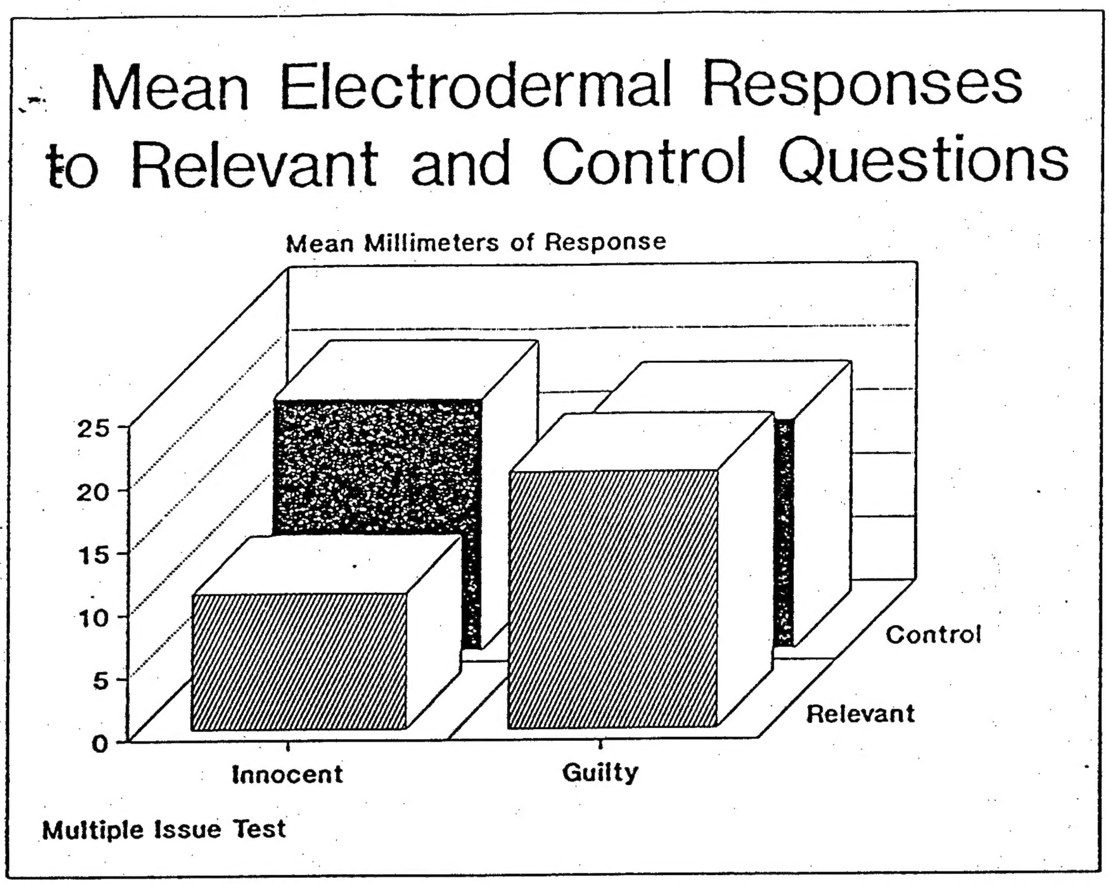

Figure 3. Mean millimeters of electrodermal response amplitude to relevant and control questions in the multiple issue condition.

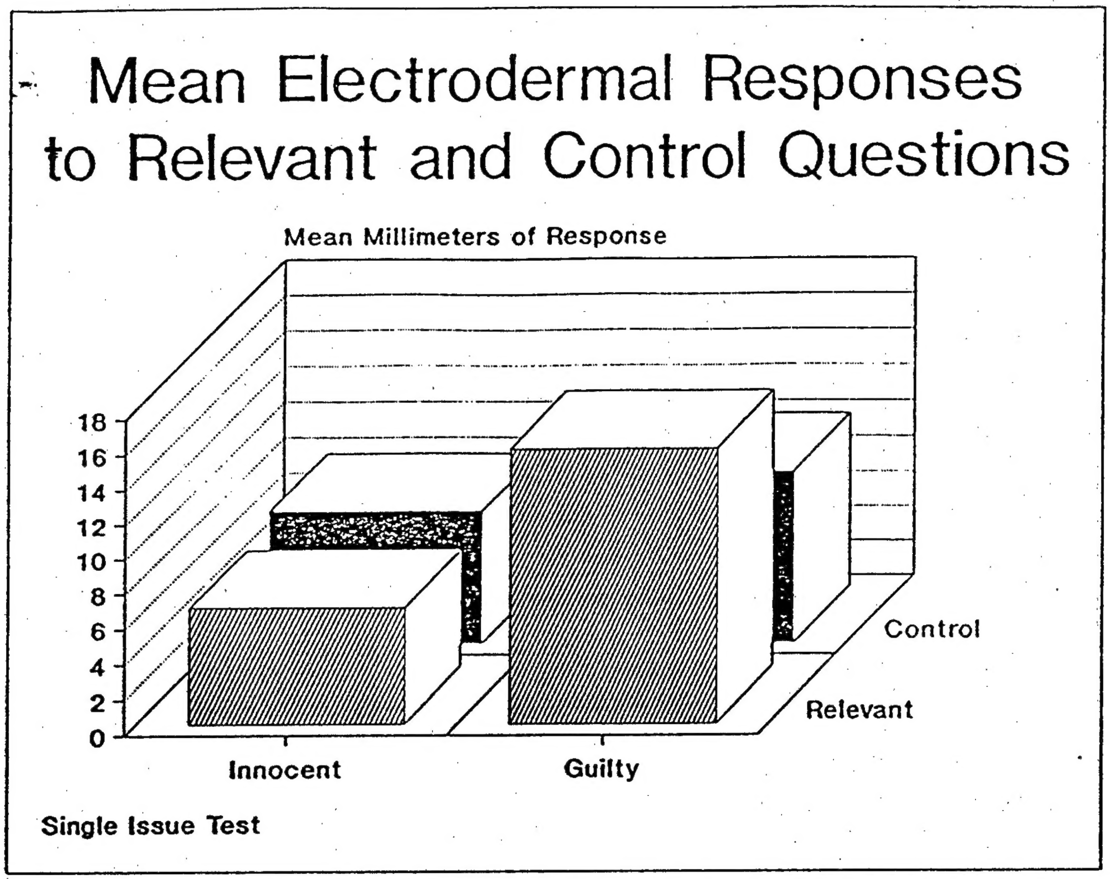

Figure 4. Mean millimeters of electrodermal response amplitude to relevant and control questions in the single issue condition.

Discussion

The constant voltage circuit (GSG) appears to offer both conceptual and practical advantages over the standard constant current circuit (GSR) presently used by most Federal examiners. Conceptually, the constant voltage circuit is more simply related to the physiological activity of interest. From a practical standpoint, the constant voltage circuit required only about half as much centering adjustment as did the constant current circuit without a loss in sensitivity. These factors support the use of the constant voltage circuit in field applications.